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ORIGINAL ARTICLE

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Prevalence of concomitant sleep disorders in patients with obstructive sleep apnea

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Abstract We determined the prevalence of concomitant sleep disorders in patients with a primary diagnosis of obstructive sleep apnea (OSA). We retrospectively analyzed 643 patients, aged ≥18, with a primary diagnosis of OSA, evaluated by sleep specialists, in whom clinical and polysomnographic data were derived using standardized techniques by reviewing data from a standardized database and clinical charts. Concomitant sleep disorders were listed according to the International Classification of Sleep Disorders (American Academy of Sleep Medicine, 2000). The mean age was 48.5±13.5 years and 55% were male. Racial distributions were African–Americans 51.8% and Caucasian 47%. Indices of disordered breathing were respiratory disturbance index 32.4±30.4/h sleep and time <90% O_2 saturation 44.5±81.6 min. Thirty-one percent of patients had a concomitant sleep disorder. The most common were inadequate sleep hygiene (14.5%) and periodic limb movement disorder (PLMD, 8.1%). Of patients with other sleep disorders, 66.8% had treatment initiated for these disorders. Predictors of inadequate sleep hygiene (logistic regression) were: age (each decade OR=0.678, *P*=0.000000), gender (for M, OR=0.536), and the presence of at least one other major system disorder (OR=2.123, *P*=0.0015). Predictors of PLMD were: age (each decade OR=0.794, *P*=0.0005), gender (for M, OR=0.433, *P*=0.004), and total sleep time (for each 10 min, OR=0.972, *P*=0.0013). We conclude that approximately one third of patients with sleep apnea have another identifiable sleep disorder, usually requiring treatment. This suggests that practitioners evaluating and treating sleep apnea ought to be prepared to deal with other sleep disorders as well.

Keywords Obstructive sleep apnea · Concomitant sleep disorders · Inadequate sleep hygiene · Periodic limb movement disorder

Introduction

The demand for health care services related to sleep disorders, especially sleep apnea, is growing. For example, the American Academy of Sleep Medicine reports 228 accredited laboratories in 1993, increasing to 805 by the end of 2004 (AASM data). The number of unaccredited laboratories is not known, but is likely to be at least as great. Physicians certified in sleep medicine usually manage sleep disorders centers. Access to specialist care and laboratory services may be difficult for some patients, and often, non-specialists utilize sleep laboratory services and manage sleep disorders without referring patients to a sleep specialist. The demand for health care services related to sleep begins with a patient report of or physician questions about the symptoms and signs of sleep apnea. Often, this occurs in the primary care physician's practice. In fact, there are data suggesting that the prevalence of obstructive sleep apnea (OSA) in primary care offices is higher than that in the general community [1]. Studies have documented sub-

optimal understanding on the part of practitioners regarding essential elements or the implications and ramifications of sleep disorders [2–4]. This may, in part, relate to under-representation of sleep and sleep disorders in most medical school curricula [5].

For many patients, especially those being managed by primary care physicians, symptoms of OSA are those driving patients to seek care. This is justified since OSA engenders increased risk of hypertension, myocardial infarction, heart failure, cardiac arrhythmias, stroke, decreased quality of life, and neurocognitive deficits [6–9]. The prevalence of sleep apnea is estimated to be 4% in men and 2% in women [10], and greater in certain subpopulations [10] and the elderly. There are, however, 88 ICD-9 codes (International Classification of Diseases, 9th revision) listed for sleep-related diagnoses [11]. The primary care practitioner may not be optimally prepared to deal with many of these. A recently published study showed that patients with OSA cared for by primary care practitioners as opposed to sleep specialists had less timely evaluations and were less aware of the severity of their disease [12].

It is likely that OSA patients with concomitant sleep disorders should have these addressed as well as the primary disorder. For example, many patients with sleep-related breathing disorders also demonstrate periodic limb movement disorder (PLMD) [12–15], which could conceivably affect symptoms and treatment outcomes. The variety and prevalences of other sleep disorders in patients with OSA are not well known. This could impact on the role of the sleep professional and the role of extended versus simplified polysomnographic studies in the routine evaluation of patients with OSA. In this study, we reviewed the experience of a cohort of well characterized patients with documented OSA. We describe the variety and prevalences of concomitant sleep disorders in this referral population. We also describe the incidence for which concomitant sleep disorders were considered to be clinically significant enough to require treatment. Finally, we determined the predictors of the most frequent concomitant sleep disorders in OSA patients.

Patients and methods

The Institutional Review Board of the University of Maryland Medical Center approved all methods described in this report. HIPPA regulations were adhered to. All data were gathered at the University of Maryland Sleep Disorders Center, an AASM accredited sleep disorders center and laboratory.

Records of 1,162 consecutive patients, ≥18 years old, seen at the University of Maryland Sleep Disorders Center from June 2002 to June 2004, were reviewed from a database. The database contains laboratory records of all patients studied in the sleep disorders laboratory. It also contains clinical data of patients evaluated by one of four sleep practitioners in the sleep disorders center. It does not contain clinical data for patients studied in the sleep laboratory evaluated by other physicians. The database codes sleep and disorders according to the International Classification of Sleep Disorders [11] and also other major system illnesses. Disorders are listed as the primary sleep disorder if it is felt by the clinician that this is clinically the most important sleep disorder.

Patients were included if the primary sleep disorder was listed as OSA. We excluded patients with primarily central sleep apnea, or Cheyne–Stokes respiration (eight patients). Among these records, 643 had a primary diagnosis of OSA, and had records including a detailed history and physical examination by a sleep specialist, polysomnographic data, and sufficient follow-up information to determine whether all listed sleep-related diagnoses besides OSA were evaluated and treated. Two hundred and one patients had a primary sleep diagnosis other than OSA. The remainder of the records did not contain clinical information and/or follow-up data detailed enough to determine whether there was another sleep disorder and if it was treated. These were either patients who did not return to follow-up or patients of physicians who ordered sleep studies in the laboratory, but whose office records were not accessible from the sleep center's database.

All sleep diagnostic procedures are conducted consistent with AASM guidelines [16]. Polysomnography was performed according to commonly accepted clinical standards [17, 18]. The montage included electroencephalography (EEG) leads O1A2, O2A1, C1A2, C2A1, LOC, ROC, submentalis electromyography (EMG), leg EMG (tied leads left four and right), electrocardiography (ECG), nasal airflow (nasal air pressure) and oronasal airflow (thermistor—used for back-up), rib cage and abdominal respiratory effort (strain gauges), and pulse oximetry. Sleep scoring was done in 30-s epochs according to the system of Rechtshaffen and Kales [18]. Respiratory events were scored as apneas (decrease in airflow to ≤10% of baseline for ≥10 s) or hypopneas (decrease in airflow to 10–70% of baseline for ≥10 s, associated with arousals or desaturation by at least 3%). Periodic limb movements were scored only if: (1) movements lasted 0.5–5 s; (2) occurred between 5–90 s apart; (3) occurred in groups of four or more; (4) did not occur in association with disordered breathing events, including apneas, hypopneas, inspiratory flow limitation, or O_2 desaturations.

Sleep apnea severity was quantified as the *respiratory disturbance index* (RDI), set equal to the number of apneas plus the number of hypopneas per hour of sleep. Desaturation was quantified as the time spent ≤90% O_2-saturated during sleep (T90). For this study, patients were given the primary diagnosis of OSA if they had an RDI≥5 and at least 75% of the apneic events were obstructive. Inspiratory flow limitation is noted on the nasal airflow cannulae. However, these events are not counted as part of the RDI.

Diagnosis of concomitant sleep disorders Due to overlapping symptoms, the diagnosis of a concomitant sleep disorder in patients with OSA may be difficult. All sleep disorders are diagnosed in keeping with the guidelines set out in the International Classification of Sleep Disorders [11]. In particular, the diagnosis of inadequate sleep hygiene was made on the basis of detailed sleep history and sleep logs. The diagnosis of PLMD was made based on the polysomnographic findings noted above. In many cases, the diagnosis was not made until periodic limb movements were "unmasked" on the continuous positive airway pressure (CPAP) titration study. For the purposes of analysis, patients with restless legs syndrome (RLS) were grouped with patients having PLMD, as all of the RLS patients (N=9) showed periodic limb movements on the polysomnograms. The diagnosis of concomitant narcolepsy was made in cases of OSA only if: (1) excessive daytime sleepiness persisted in spite of adequate treatment with CPAP (clinical history); (2) adequate control of disordered breathing events was documented on a full-night polysomnogram using CPAP; (3) mean sleep latency was ≤5 min and there were two or more sleep onset rapid eye movement (REM) periods on a multiple sleep latency test (MSLT) following that polysomnogram; (4) either cataplexy was present or at least two minor symptoms of narcolepsy persisted following treatment for OSA. Similarly, concomitant idiopathic hypersomnia was diagnosed only if: (1) excessive daytime sleepiness persisted in spite of adequate treatment with CPAP (clinical history); (2) adequate control of disordered breathing events was documented on a full-night polysomnogram using CPAP; (3) mean sleep latency was ≤5 min MSLT following that polysomnogram; (4) there was no other explanation for persistent excessive sleepiness. The diagnosis of concomitant "primary insomnia" was made only if: (1) insomnia was part of the presenting complaint; (2) insomnia symptoms persisted with adequate CPAP therapy (clinical history); (3) patients did not complain of difficulty utilizing their CPAP; (4) there was no other clinically apparent cause of insomnia. Thus, in many cases, concomitant disorders could be diagnosed only after CPAP treatment was initiated, compliance was reported to be adequate, and, in some cases, the adequacy of treatment documented on follow-up polysomnography.

Diagnosis of concomitant major system disorders A concomitant major system disorder was listed only if the patient reported that a physician had given a diagnosis or the patient was receiving prescription medication specific for this disorder.

Treatment of concomitant sleep disorders Concomitant sleep disorders were considered "treated" when the attending sleep physician initiated or changed the therapy for a given disorder. Institution of appropriate medication for a concomitant sleep condition would be one example. For patients with inadequate sleep hygiene, "appropriate therapy" consists of extensive counseling on sleep hygiene measures, documented as such in the chart, the handing out of educational materials, and, in many cases, the referral for specific sleep hygiene follow-up to a nurse-practitioner-run sleep hygiene clinic. For most disorders leading to chronic insomnia, cognitive–behavioral therapy by a nurse practitioner was also part of the therapeutic regimen.

Information on demographics and polysomnographic data were entered into the database along with appropriate clinical data extracted from the patient's chart. Demographics included age, race, gender, and body mass index (BMI). Data on the presence of concomitant sleep disorders and concomitant major medical disorders were also entered onto the database, along with whether treatment was undertaken for concomitant sleep disorders. Specific sleep and polysomnographic data were recorded, including: Epworth sleepiness score, total sleep time, sleep latency, percent of slow wave sleep, percent of REM sleep, T90, RDI, and RDI in REM sleep.

Data analysis

The numerical data were expressed as mean±SD. Differences in frequencies of concomitant disorders based on race and gender were compared using the χ^2 test (Yates' correction applied when appropriate). For binary outcomes, logistic regression was used to determine the predictors of the outcome. The null hypothesis was rejected at the 5% level.

Results

Table 1 shows the population demographics and sleep data. The referral population had a slight male and African–American predominance, and the mean RDI was in the severe range. A total of 235 concomitant sleep disorders were found among 199 (31.0% of the total) patients with OSA. Table 2 lists the prevalences of concomitant sleep disorders in decreasing order of frequency. The two most common concomitant sleep disorders were inadequate sleep hygiene and PLMD. Among the 52 patients with PLMD, nine (17.3%) had waking symptoms consistent with RLS, and all had periodic limb movements at polysomnography. Among the patients with PLMD, the mean periodic limb movement index (movements per hour of sleep) was 20.6±17.8.

The chart review revealed that, in 157 among the 235 (66.8%) concomitant sleep disorders, treatment was initiated by the attending sleep physician. For the two most common diagnoses, 86% of the patients with inadequate sleep hygiene had documentation of treatment as outlined above. For patients with PLMD, 47% had their treatment documented. Patients were treated for concomitant PLMD only if there were persistent symptoms, such as excessive

Table 1 Demographics and sleep study data

Variable (*N*=643)	Mean±SD
Age (years)	48.5±13.5
Male (%)	55
BMI (kg/m^2)	36.7±10.7
Race	
African–American (%)	51.8
Caucasian (%)	47
Hispanic (%)	0.16
Asian (%)	0.10
Epworth sleepiness score	12.4±5.6
Total sleep time (min)	328.2±74.0
Sleep efficiency (%)	80.7±14.7
Sleep latency (min)	19.5±29.1
RDI	32.4±30.4
REM RDI	36.1±29.7
Slow-wave sleep (%)	14.0±1.1
REM (%)	20.0±1.1
T90 (min)	44.5±81.6

T90=time less than 90% O_2-saturated during sleep
BMI Body mass index; *REM* rapid eye movement sleep

daytime sleepiness, that, in the opinion of the clinician, were attributable to periodic limb movements. In most cases, this was only after OSA was considered to be adequately treated. This is consistent with the practice policy of this center. In five individuals, treatment for PLMD was undertaken concomitantly with treatment for OSA. These individuals all had PLM indices greater that 20, with clear-cut sleep fragmentation unrelated to disordered breathing events during these epochs.

Table 3 gives the prevalences of the eight most common other major system disorders. The four most common major system disorders were hypertension, diabetes, obstructive lung disease, and depression/anxiety.

Table 4 shows the racial, gender, and age distributions of the two most common concomitant sleep disorders in the OSA patients; inadequate sleep hygiene and PLMD. Men were less likely to have a diagnosis of inadequate sleep hygiene and PLMD than women. Caucasians were less likely to have a diagnosis of inadequate sleep hygiene, but more likely to have a diagnosis of PLMD. Other racial groups were not analyzed because of their small numbers. Older individuals were less likely to have inadequate sleep hygiene than younger individuals. We compared the frequency of PLMD in two ways. Using the median age (50 years old), we found no significant age distribution. However, comparing individuals in the lower 25% (≤39 years old) and the upper 25% (≥58 years old) of the age group showed a significant increase in the frequency of PLMD in younger individuals.

Using logistic regression, we determined the predictors of the most common concomitant sleep disorder, inadequate sleep hygiene. The model included: age, gender, race, the presence of PLMD, the presence of other major system disease, the Epworth sleepiness score, sleep efficiency, percent slow wave, percent REM, T90, RDI, BMI,

Table 2 Prevalence of concomitant sleep disorders in patients with OSA

Disorder	Number	Prevalence among other disorders (%)	Prevalence among the total cohort (%)
Inadequate sleep hygiene	93	41.7	14.5
Periodic limb movement disorder	52	23.3	8.1
Narcolepsy	16	7.2	2.5
Primary (idiopathic) insomnia	14	6.3	2.2
Central alveolar hypoventilation	9	4.0	1.4
Shift work disorder	5	2.2	0.8
Psychophysiological insomnia	5	2.2	0.8
Bruxism	5	2.2	0.8
Idiopathic hypersomnia	4	1.8	0.6
Sleepwalking	3	1.3	0.5
Sleep talking	3	1.3	0.5
Environmental sleep disorder	3	1.3	0.5
Hypnotic dependent sleep disorder	3	1.3	0.5
Delayed sleep phase syndrome	3	1.3	0.5
Toxin dependent sleep disorder	1	0.4	0.2
Sleep terrors	1	0.4	0.2
Nightmares	1	0.4	0.2
Enuresis	1	0.4	0.2
Confusional arousals	1	0.4	0.2

Table 3 Prevalences of other major medical disorders among OSA patients

Disorder	Number	Prevalence (%)
Hypertension	211	32.2
Diabetes	73	11.4
Obstructive lung disease	60	9.3
Depression/anxiety	59	9.2
Congestive heart failure	17	2.6
Fibromyalgia	9	1.4
Renal disease	8	1.2
Alcohol abuse	4	0.6

Table 4 Racial and gender distribution among other concomitant sleep disorders

Disorder	Distribution		Number/number of patients for whom data are available	Percentage (%)	*P* value
Inadequate sleep hygiene	Gender	Male	38/354	10.7	<0.01
		Female	52/289	18.0	
	Race	Caucasian	27/302	8.9	<0.004
		African–American	63/333	18.9	
	Age	≤50	55/344	16.0	<0.0001
		>50	35/299	11.7	
PLMD	Gender	Male	20/354	5.6	0.0416
		Female	29/289	10.0	
	Race	Caucasian	37/302	12.3	<0.0001
		African–American	12/333	3.6	
	Age	≤50	22/344	6.4	NS
		>50	27/299	9.0	
		≤39	41/151	27.2	<0.0001
		≥58	11/149	27.2	

and total sleep time. The only significant predictors of inadequate sleep hygiene were age (for each decade increase in age OR=0.678, CI 0.624–0.738, *P*=0.000000), female gender (for M, OR=0.536, CI 0.345–0.842, *P*=0.0054), and the presence of at least one other major system disorder (OR=2.123, CI=1.331–3.386, *P*=0.0015). Because the numbers were smaller, we did not determine the predictors of other concomitant sleep disorders.

Similarly, we determined the predictors of the PLMD. The model included age, gender, race, the presence of other major system disease, the Epworth sleepiness score, sleep efficiency, percent slow wave, percent REM, T90, RDI, BMI, and total sleep time. The only significant predictors were age (for each decade, OR=0.794, CI=0.697–0.904, *P*=0.0005), gender (for M, OR=0.433, CI=0.244–0.767, *P*=0.004), and total sleep time (for each 10 min increase in the total sleep time, OR=0.972, CI=0.955–0.989, *P*=0.0013).

Discussion

This study shows that 31% of patients with a diagnosis of obstructive sleep apnea (OSA) have a concomitant sleep disorder. The most common were inadequate sleep hygiene and periodic limb movement disorder (PLMD), with a variety of other disorders listed. Approximately two thirds of the concomitant disorders were considered severe enough by the attending sleep specialist to require initiating specific treatment. With few exceptions, the list of concomitant sleep disorders consists of conditions not likely detected in routine examinations given in primary care or even non-sleep specialist settings. Although sleep history (including logs) is adequate for the diagnosis of inadequate sleep hygiene, for most of the rest of the listed disorders, polysomnography is an important adjunct or even necessary for the diagnosis. Thus, many patients with OSA might be optimally served by addressing their concomitant sleep diagnosis in addition to OSA.

The current study includes patients evaluated at a university-based referral center. Thus, it may not represent patients drawn from the general population. For example, 2.5% of our OSA patients had concomitant narcolepsy. This is far greater than general population estimates [19, 20], and most likely reflects the referral nature of an academic sleep disorders center. As an example, a large multi-center survey of regional, presumably referral, sleep disorders centers reported a narcolepsy prevalence of 3.2%, similar to that reported here in our patients [21].

The most common concomitant sleep disorder was inadequate sleep hygiene, accounting for 14.5% of the total cohort and 41.7% of the patients with concomitant sleep disorders. Interestingly, there are few previous data concerning the incidence and efficacy of treating inadequate sleep hygiene in the general population or in sleep referral populations [22]. Mendelson [23] reported a prevalence of this syndrome in only 3% among 1,700 patients, although sleep hygiene therapy was recommended in 11.9% of the patients, possibly reflecting the true prevalence in his patients. The number of patients with concomitant OSA was not reported. Redline et al. [24] reported that counseling about sleep posture and sleep hygiene led to an improvement in quality of life in 26% of their patients with mild sleep apnea (defined as respiratory disturbance index, RDI <30) not treated with continuous positive airway pressure (CPAP). Possibly, this represents an upper limit for the prevalence of inadequate sleep hygiene in patients with OSA.

We found that inadequate sleep hygiene was preferentially found in younger patients, females, and African–Americans. The reasons for this are not clear. However, possibilities include greater household and child-rearing responsibilities for women, lifestyle issues related to economic stratification in the African–Americans in our study

population [25], and possibly less attention paid to adequate lifestyles in younger patients. On the other hand, logistic regression failed to confirm a racial distribution for the occurrence of inadequate sleep hygiene. This may be due to the fact that, as previously reported in our patients [25], Africa–American patients tended to be younger than Caucasians (current study: African–Americans 47.4±12.9, Caucasians 49.8±13.9 years), and the racial distribution may, in fact, have been a reflection of age distribution. Logistic regression did demonstrate that the presence of other systemic disease was a robust predictor of inadequate sleep hygiene. This may represent the effects of symptoms of other disease, medication effects, or other lifestyle disruptions in patients with OSA and other major system diseases. It must be noted that inadequate sleep hygiene is a diagnosis usually made after careful sleep history is taken. This argues for increased education of non-specialists in the elements of a good sleep history or referral of many patients with sleep-disordered breathing to a practitioner skilled in the taking of a sleep history. However, there are few data examining the outcomes in patients with concomitant sleep disorders treated by primary versus specialist physicians.

The association between OSA and PLMD has been noted in numerous publications [13–15, 26–32]. Reported prevalences range from 5.1% to 69%. Differences in reported prevalences likely represent differences in population base, and the definition of periodic limb movements. We were careful to exclude patients who had leg movements associated with OSA events. It has been noted that treatment with CPAP may, in some instances, "unmask" the presence of PLMD [30, 32]. This appears to be due to the emergence of the periodic limb movement pacemaker once apneic events are suppressed. PLMD can lead to sleep fragmentation and excessive sleepiness, and may act synergistically with OSA to produce symptoms. PLMD can only be diagnosed by polysomnography. Since 8.1% of patients with OSA have PLMD as well, it would seem prudent to consider this as a concomitant diagnosis for patients who are failing to respond to therapy for CPAP. Polysomnography, including leg movements and electroencephalography (EEG), should be obtained if not already done as part of the evaluation for OSA.

As previously described for the general population [27], the female gender was associated with an increase in the prevalence of PLMD. However, unlike Ohayon and Roth [27], we found a *decrease* in PLMD prevalence in older individuals compared to younger ones. The reasons for the discrepancy between our study and the cited study [27] are not clear. Possibly, individuals with OSA and PLMD seek medical care at a younger age because their symptoms are more troubling. Finally, we found that, with greater total sleep time, there was a decrease in the prevalence of PLMD in our OSA patients. Again, the explanation is not clear. Possibly, longer total sleep time is necessary to "make up" for additional sleep fragmentation due to PLMD.

That the attending clinicians felt the presence of other sleep disorders were important is attested to by the fact that approximately two thirds of patients (66.8%) had treatment initiated for these disorders. This argues for the clinical importance of concomitant sleep disorders.

In conclusion, almost one third of patients with OSA had a concomitant sleep disorder, the most common being inadequate sleep hygiene and PLMD. The question of the role of the sleep specialist and polysomnographer in the evaluation of patients with sleep-disordered breathing is impacted by these findings. Compared with primary care practitioners, sleep specialists give more timely evaluations and patients are more educated about their disease [12]. In the current article, we have determined that a large minority of the patients with a primary diagnosis of OSA will require the services of a sleep specialist, assuming that generalists do not take the same detailed sleep histories and do not deal with concomitant sleep disorders in the same manner as sleep specialists. These data argue for the position that sleep specialty care should be available for all segments of the population, and a strong referral connection should exist between the primary care physician and the sleep specialist.

References

1. Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP (1999) Using the Berlin questionnaire to identify patients at risk for the sleep apnea syndrome. Ann Intern Med 131:485–491
2. Haponik EF, Frye AW, Richards B, Wymer A, Hinds A, Pearce K, McCall V, Konen J (1996) Sleep history is neglected diagnostic information: challenges for primary care physicians. J Gen Intern Med 11:759–761
3. Chung SA, Jairam S, Hussain MR, Shapiro CM (2001) Knowledge of sleep apnea in a sample grouping of primary care physicians. Sleep Breath 5:115–121
4. BaHammam AS (2000) Knowledge and attitude of primary health care physicians towards sleep disorders. Saudi Med J 21:1164–1167
5. Rosen RC, Rosekind M, Rosevear C, Cole WE, Dement WC (1993) Physician education in sleep and sleep disorders: a national survey of U.S. medical schools. Sleep 16:249–254
6. Young T, Peppard P, Gottlieb D (2002) Epidemiology of obstructive sleep apnea: a population health perspective. Am J Respir Crit Care Med 165:1217–1239
7. Bassiri A, Guilleminault C (2000) Clinical features and evaluation of obstructive sleep apnea-hypopnea syndrome. In: Kryger M, Roth T, Dement W (eds) Principles and practice of sleep medicine, 3rd edn. WN Saunders, Philadelphia, pp 869–878

8. Nieto FJ, Young TB, Lind BK, Shahar E, Samet JM, Redline S, D'Agostino RB, Newman AB, Lebowitz MD, Pickering TG (2000) Association of sleep-disordered breathing, sleep apnea, and hypertension in a large community-based study: sleep heart health study. JAMA 283:1829–1836
9. Jenkinson C, Davies RJ, Mullins R, Stradling JR (1999) Comparison of therapeutic and subtherapeutic nasal continuous positive airway pressure for obstructive sleep apnoea: a randomized prospective parallel trial. Lancet 353:2100–2105
10. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S (1993) The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 328(17):1203–1235
11. American Academy of Sleep Medicine (2000) ICSD—international classification of sleep disorders, revised: diagnostic and coding manual. American Academy of Sleep Medicine
12. Scharf SM, DeMore J, Landau T, Smale P (2004) Comparison of primary care practitioners and sleep specialists in the treatment of obstructive sleep apnea. Sleep Breath 8:111–124
13. Exar EN, Collop NA (2001) The association of upper airway resistance with periodic limb movements. Sleep 24:188–192
14. Carelli G, Krieger J, Calvi-Gries F, Macher JP (1999) Periodic limb movements and obstructive sleep apneas before and after continuous positive airway pressure treatment. J Sleep Res 8:211–216
15. Baran AS, Richert AC, Douglass AB, May W, Ansarin K (2003) Change in periodic limb movement index during treatment of obstructive sleep apnea with continuous positive airway pressure. Sleep 26:717–720
16. Chesson AL Jr, Ferber RA, Fry JM, Grigg-Damberger M, Hartse KM, Hurwitz TD, Johnson S, Kader GA, Littner M, Rosen G, Sangal RB, Schmidt-Nowara W, Sher A (1997) The indications for polysomnography and related procedures. Sleep 20:423–427
17. Carskadan MA, Rechtschaffen A (2000) Monitoring and staging human sleep. In: Kryger M, Roth T, Dement W (eds) Principles and practice of sleep medicine, 3rd edn. Saunders, Philadelphia, pp 1197–1215
18. Rechtshaffen A, Kales A (eds) (1968) A manual of standardized terminology: techniques and scoring system for sleep stages of human subjects. US Department of Health, Education and Welfare, Public Health Service–National Institutes of Health. Neurological Information Network. Bethesda, Maryland
19. Silber MH, Krahn LE, Olson EF, Pankratz S (2002) The epidemiology of narcolepsy in Olmsted County, Minnesota: a population-based study. Sleep 25:197–202
20. Hublin C, Partinen M, Kaprio J, Koskenvuo M, Guilleminault C (1994) Epidemiology of narcolepsy. Sleep 17 (8 Suppl):S7–S12
21. Punjabi NM, Welch D, Strohl KP (2000) Sleep disorders in regional sleep centers: a national cooperative study. Sleep 23:471–480
22. Shneerson J, Wright J (2004) Lifestyle modification for obstructive sleep apnoea (Cochrane Review). In: The Cochrane library, vol 3. Wiley, Chichester, UK, pp 1–7
23. Mendelson WB (1997) Experiences of a sleep disorders center: 1,700 patients later. Clevel Clin J Med 64:46–51
24. Redline S, Adams N, Strauss ME, Roebuck T, Winters M, Rosenberg C (1998) Improvement of mild sleep-disordered breathing with CPAP compared with conservative therapy. Am J Respir Crit Care Med 157:858–865
25. Scharf SM, Seiden L, DeMore J, Carter-Pokras O (2004) Racial differences in clinical presentation of patients with sleep disordered breathing. Sleep Breath 8:173–183
26. App WE, Boatwright GW, Ostrander SE, Unruh MM, Winslow DH (1990) Disorders of excessive daytime somnolence: a case series of 1,000 patients. J Ky Med Assoc 88:393–396
27. Ohayon MM, Roth T (2002) Prevalence of restless legs syndrome and periodic movement disorder in the general population. J Psychosom Res 53:547–554
28. Ancoli-Israel S, Kripke DF, Mason W, Kaplan OJ (1985) Sleep apnea and periodic movements in an aging sample. J Gerontol 40:419–425
29. Carelli G, Krieger J, Calvi-Gries F, Macher JP (1999) Periodic limb movements and obstructive sleep apnea before and after continuous positive airway pressure treatment. J Sleep Res 8:211–216
30. Baran AS, Richert AC, Bouglass AB, May W, Ansarin K (2003) Change in periodic limb movement index during treatment of obstructive sleep apnea with continuous positive airway pressure. Sleep 26:717–720
31. Coleman RM, Pollak CP, Weitzman ED (1978) Periodic movements in sleep (nocturnal myoclonus): relation to sleep disorders. Trans Am Neurol Ass 103:230–233
32. Fry JM, DiPhillipo MA, Pressman MR (1989) Periodic leg movements in sleep following treatment of obstructive sleep apnea with nasal continuous positive airway pressure. Chest 96:89–91